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A REVIEW OF THE COLUMBARIINAE (GASTROPODA: TURBINELLIDAE) OF THE WESTERN ATLANTIC WITH NOTES ON THE ANATOMY AND SYSTEMATIC RELATIONSHIPS OF THE SUBFAMILY

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INTRODUCTION

The subfamily Columbariinae encompasses a small, poorly known, morphologically compact group of fusiform marine rachiglossan gastropods that inhabit areas of the outer continental shelf and upper continental slope. Known from the Upper Cretaceous (Maestrichtian) of the Netherlands, the group first appears in the western Atlantic during the Paleocene (Midway Group of Alabama), but is not represented in the fossil record of the region after the Eocene.

The group's taxonomic placement within the Neogastropoda has undergone considerable peregrination. The status of the seven supraspecific taxa has also been subject to varying interpretations.

Anatomical investigations have, for the most part, been limited to studies of radular morphology. Ponder (1973) discussed the alimentary system of two species of *Coluzea* in a paper dealing with the evolution of the Neogastropoda.

On the basis of new data provided by anatomy, diet, SEM micrographs of radulae, and shell characters, I suggest that the group does not merit family status, but rather, is part of the vermivorous turbinellid radiation that took place in the late Mesozoic. A revision of the western Atlantic species is proposed, three new species are described, and the evolution and zoogeography of the subfamily are discussed.

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TAXONOMIC HISTORY

Although several species referable to Columbariinae had been previously described in the genus *Fusus* (Lesson, 1834; Deshayes, 1835), Martens (1881) was the first to recognize the group as distinct. He proposed *Columbarium* as a subgenus of *Pleurotoma* [type species *Pleurotoma (Columbarium) spinicincta* Martens, 1881] based on Schacko's (in Martens, 1881) identification of the long, tubular structures taken from the proboscis of the type species as toxoglossan radular teeth. Some authors accepted this placement (Fischer, 1883; Tryon, 1884; Martens 1901; Dall, 1918), but others either retained *Fusus* (Watson, 1882; Tate, 1888) or placed *Columbarium* within Fusidae (=Fusininae) (Cossmann, 1896, 1901).

In 1922 Peile reported that the radula of *Columbarium pagoda* (Lesson, 1834) was rachiglossate and placed *Columbarium* near the Muricidae, further suggesting that Schacko's figures represented crustacean remains. Thiele (1925) reexamined Schacko's slide and concluded that the objects on it were not radular teeth. After examining the radulae of two additional species, he placed the genus *Columbarium* in the Muricidae between *Typhis* and *Murex*.

Tomlin (1928) erected the family Columbariidae on grounds that, while sharing some characters with Muricidae and Buccinidae, *Columbarium* was not referable to either of these families. The following year, Thiele reduced Columbariidae to a genus within Muricidae. Finlay (1930) recognized the family, and included in it the genera *Fulgurofusus* [erected by Grabau (1904) for a Paleocene species he believed to be ancestral to Busyconinae] and *Coluzea* (a fossil and Recent New Zealand genus that Finlay had proposed in 1927).

With the exception of Wenz (1941), who considered the Columbariinae a subfamily of Muricidae, subsequent workers have accorded the group family level status (Iredale, 1936; Finlay and Marwick, 1937). Clench (1944) reviewed the newly discovered western Atlantic species, Dell (1956) was the first to describe the radula of *Coluzea*, and Barnard (1959) added to our knowledge of the South African species.

In a major revision of the family, Darragh (1969) proposed three new genera: *Hispidofusus, Serratifusus* and *Histricosceptrum*, the first two from the Miocene of Australia, the last from the Recent of the western Atlantic and Indian Oceans. Reporting on the mollusks collected during the University of Miami deep-sea expeditions, Bayer (1971) reduced all supraspecific taxa to subgenera of *Columbarium,* and added the subgenus *Peristarium* to include 3 new species that strongly resemble *Fusinus*, but have distinctly columbariid radulae and protoconchs. Ponder (1973) showed that the alimentary system of *Coluzea* possessed muricid as well as buccinid features, and concluded that family status was justified.

MATERIALS AND METHODS

I was fortunate in being able to examine most of the known specimens of western Atlantic Columbariinae, including all holotypes and all but 3 paratypes. Among the material collected by R/V JOHN ELLIOT PILLSBURY were several preserved specimens of *Fulgurofusus brayi.* Most had been partially dissected and the radulae had been removed, but there remained a single intact specimen still in its shell. Several fragments of this shell were broken off near the outer lip, in order to examine shell ultrastructure. The specimen was then immersed in 10% hydrochloric acid until the shell dissolved. The operculum was removed and the animal was imbedded in polyester resin, sectioned at 8 μm and stained with Mallory Triple Connective Tissue Stain.

Specimens of other species that contained dried animals were reconstituted in a solution of trisodium phosphate, and gross features of their mantle cavities, and reproductive and alimentary systems were studied before extracting the radulae.

Radulae and shell ultrastructure were examined using a Zeiss Novascan 30 Scanning Electron Microscope.

With the exception of the holotype of *Fulgurofusus sarissophorus*, all shells were coated with ammonium chloride before being photographed.

Abbreviations used within the text are as follows: AMNH, American Museum of Natural History; BM(NH), British Museum (Natural History); DMNH, Delaware Museum of Natural History; IRCZM, Indian River Coastal Zone Museum; MCZ, Museum of Comparative Zoology; UMML University of Miami Marine Laboratory; USNM, former United States National Museum, collections in National Museum of Natural History, Smithsonian Institution.

SYSTEMATICS

Order NEOGASTROPODA

Family TURBINELLIDAE Swainson, 1840

This family, best known for its large, shallow-water members, is characterized by thick, spindle-shaped shells that have large, bulbous protoconchs, distinct, sculptured peripheries, and open, axially-oriented siphonal canals. Shell aperture is generally ovate, the outer lip smooth; and the columella may or may not have several spiral folds. Opercula are corneous, elongate, and have a terminal nucleus. Animals have a long, narrow proboscis, a small radula with tricusped rachidia, and an open or partially fused sperm groove; they lack an accessory salivary gland; and they may or may not have an anal gland and multicusped lateral teeth. Diet consists largely or exclusively of polychaetes (Moses, 1923:106) and sipunculids (Taylor et al. 1980:377).

The nomenclatoral history of this family has been discussed by Rehder (1967:184-185). Current workers divide the family into the subfamilies Turbinellinae, Vasinae and Ptychatractinae, largely on the basis of shell and radular characters. Evidence is presented here for the inclusion of an additional subfamily, the Columbariinae.

Subfamily COLUMBARIINAE Tomlin, 1928

This subfamily, restricted to the bathyal zone in the Recent fauna, may be recognized by its small, thin, fusiform shell, which has a deviated, paucispiral protoconch, sculptured periphery, long, narrow siphonal canal and lacks columellar folds. The distinctive operculum is strongly ovate, with terminal nucleus and round or ovate attachment area. Anatomical features include a very long, thin proboscis that retracts into a non-evertable sheath, a tiny radula with tricusped rachidia and long, monocusped lateral teeth, an open sperm groove that extends to the tip of the penis, and a distinct anal gland. Rectal contents indicate a diet of tubiculous polychaetes.

As only limited anatomical material was available for study, diagnoses of phyletic relationships between supraspecific taxa are tentative. Recognition of at least two genera, *Fulgurofusus* and *Columbarium*, both well established by the Paleocene, appears to be warranted on the basis of differences in shell and radular morphology. Although both genera are represented in Tertiary deposits along the northern Gulf of Mexico, all Recent western Atlantic columbarines are attributed to *Fulgurofusus* s.l. The genus *Columbarium* appears to be restricted to the western Pacific in the Recent fauna. *Coluzea* and *Peristarium* are provisionally regarded as subgenera of *Fulgurofusus*, based on a general resemblance of shells and radulae, but additional work is required to more fully delineate the true affinities of these groups.

Cursory examination of the radulae of several South African species originally described in *Columbarium* suggests that they will prove to belong to *Fulgurofusus.*

Genus *Fulgurofusus* Grabau, 1904

SYNONYMY

1904 *Fulgurofusus* Grabau, Smithson. Misc. Collns. 44 (1407): 86. Type species by original designation: *Fusus quercollis* Harris, 1896.

1971 *Columbarium (Fulgurofusus)* Grabau, Bayer, Bull. Mar. Sci. 21(1):170.

This genus was originally proposed in Fusidae (= Fusininae) to include two Tertiary species that Grabau (1902:922; 1904:87; 1910:11-14) believed to be ancestral to Busyconinae. One of these species was subsequently transfered to the genus *Columbarium*, which differs from *Fulgurofusus* in having a more bulbous and deviated protoconch, and a thicker shell, with a strong anterior carina, triangular spines along the periphery, and scales along the spiral cords. Axial ribbing, an incised or keeled periphery, and a rachidian in which the edges of the basal plate are greatly expanded and buttressed are all characteristic of *Fulgurofusus.*

Subgenus *Fulgurofusus* s.s.

This subgenus is represented in the fossil record of the western Atlantic by 3 species: *F. quercollis*, from the Paleocene of Alabama, *F. merriami* (Dickerson, 1916), from the Lower Eocene of California, and *F. washingtonianus* (Weaver. 1912), from the Upper Eocene of Washington. Species in the Recent fauna inhabit bathyal and abyssal zones along the western Atlantic as well as off Antarctica and New Zealand. *Fulgurofusus (Fulgurofusus) benthocallis* (Melville and Standen, 1907), taken in 3210 m off the South Orkney Islands, holds the depth record for the subfamily. The flange-like peripheral keel, which may be crenulate or nodulose, is diagnostic of the subgenus. Axial sculpture, when present, is limited to weak ribs or nodes in the early whorls.

Fulgurofusus (Fulgurofusus) brayi (Clench, 1959)

Figures 1-2, 4-9, 13-20

SYNONYMY

1959 *Columbarium brayi* Clench, Johnsonia 3(39):330, pl. 173, figs. 1,2.

1969 *Fulgurofusus brayi* (Clench), Darragh, Proc. Roy. Soc. Vict. 83(1):102-103, pl.6, figs. 113,115.

1971 *Columbarium (Fulgurofusus) brayi* Clench, Bayer, Bull. Mar. Sci. 21(1):173-176, figs. 39 B, 40 A-D; 1974 Abbott, American Seashells, second edition, p.170.

DESCRIPTION — SHELL: Large for genus (to 73 mm), thin to moderately heavy, fusiform; spire angle 53°-109°; protoconch (fig.20) with 1½ whorls, bulbous, glassy; transition to teleoconch indistinct, marked by gradual acquisition of peripheral keel and increase in coarseness of growth striae; teleoconch with 7 strongly convex whorls; suture impressed; keel, rounded in first post-nuclear whorl, rapidly extends normal to the coiling axis to form a peripheral flange that may be short or nearly as wide as the aperture; spiral sculpture of fine threads to strong cords, usually most prominent adjacent to peripheral keel, and on body whorl and siphonal canal; axial sculpture limited to fine sinuate growth striae; aperture strongly ovate; outer lip smooth, unornamented, except for furrow beneath periphery; inner lip smooth, appressed posteriorly; siphonal canal long, straight, axial; shell and aperture color uniformly white; periostracum (fig.8) very thin, yellowish, with short axial blades.

ULTRASTRUCTURE: shell composed of 2 orthogonal layers of crossed-lamellar aragonite; outer layer (fig.7,XLC) with lamellar planes parallel to growing edge, fairly uniform in thickness (150-300 μm), includes spiral sculpture; inner layer (fig.7,XLT) with lamellar planes perpendicular to

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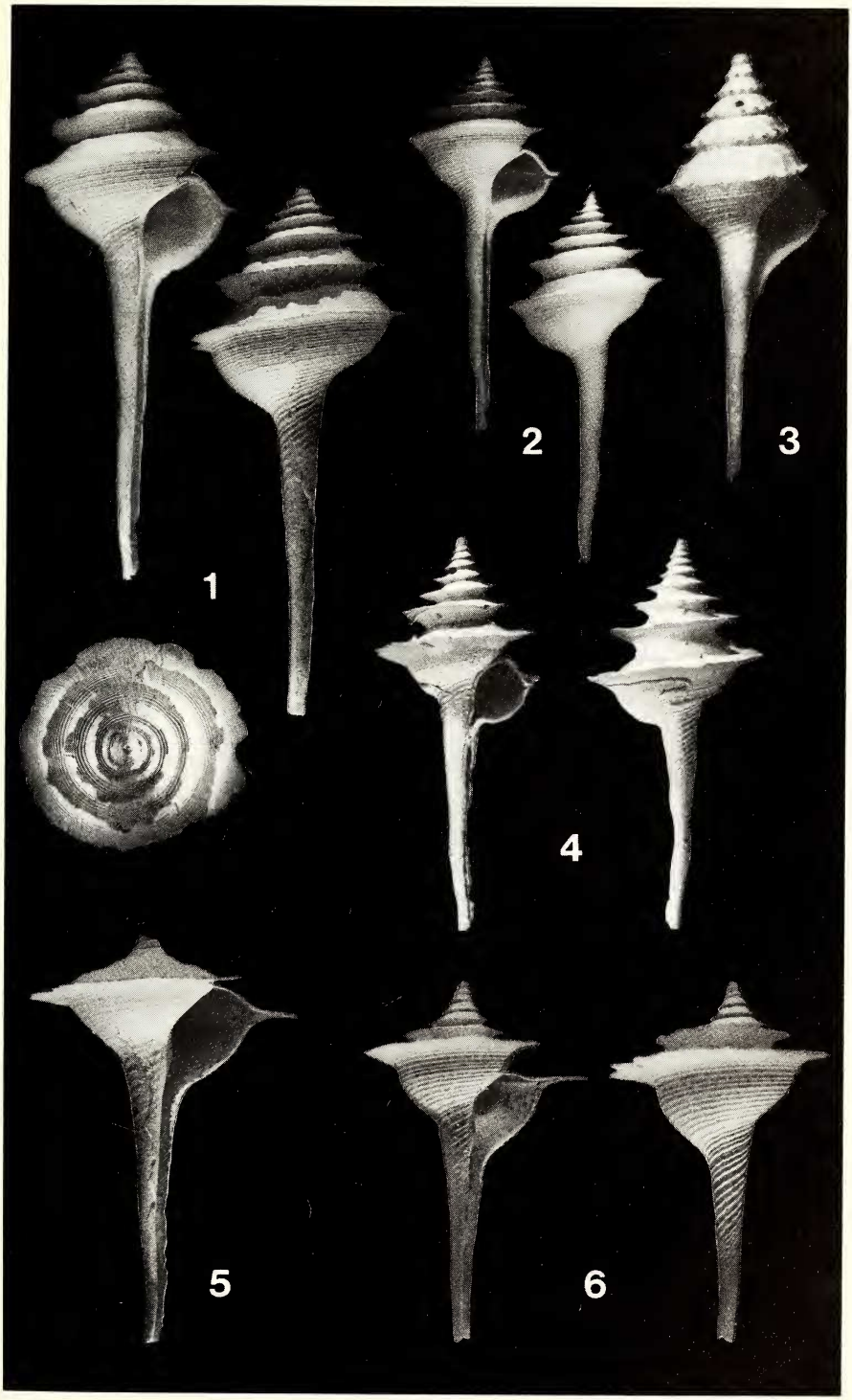
FIGS. 1-2. *Fulgurofusus (Fulgurofusus) brayi* (Clench, 1959).

1. AMNH 187174, Off Venezuela, in 342 m (1 X).
2. Holotype, MCZ 221601, ATLANTIS cruise 240, Off Cabo Codera, Venezuela, in 273 m (1 X).

FIG. 3. *Fulgurofusus (Fulgurofusus) sarissophorus* (Watson, 1882). Holotype, BM(NH) 1887.2.9.687, CHALLENGER station 122, Off Pernambuco, Brazil, in 640 m (3 X).

FIGS. 4-6. *Fulgurofusus (Fulgurofusus) brayi* (Clench, 1959).

4. IRCZM 65:1806, OREGON II station 24263, Off Nevis, Lesser Antilles, in 512-769 m (1 X).
5. DMNH 153522, PILLSBURY station P-445, ESE of Escudo de Veraguas, Panama, in 342-346 m (1.5 X).
6. USNM 806987, PILLSBURY station P-781, Off Eastern Colombia, in 567-531 m (1.5 X).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growing edge, variable in thickness (20-150 μm), thinnest at outer edge of lip, thickest along columella and inner surface of periphery.

ANIMAL — EXTERNAL FEATURES: The body consists of 2¼ whorls, of which the mantle cavity occupies ⅔ whorl, the kidney (fig.14,k) ½ whorl, and the digestive gland (fig.14,dg) about ¾ whorl. The columellar muscle is large, with a broad attachment area. The foot is long, narrow, rounded anteriorly and posteriorly, with a yellow, sharply ovate operculum. Tentacles are short and blunt, with conspicuous black eyes. The mantle edge is thin and slightly papillose, the siphon long and narrow.

MANTLE CAVITY: The mantle cavity is narrow and deep, with the pallial organs situated as in other rachiglossans (fig.14). The short (4 mm), broad (L/W = 2.2) osphradium (fig.14,os) contains 48 leaflets per side. The ctenidium (fig.14,ct), twice as long and slightly narrower than the osphradium, is composed of about 150 triangular leaflets. To the right of the transversely folded and unpigmented hypobranchial gland (fig.14,hg) lie the rectum (fig.14,r) and genital ducts. The rear of the mantle cavity is formed by the pericardium (fig.14,pc) on the left and the kidney on the right.

ALIMENTARY SYSTEM: The extremely long, narrow proboscis (fig.15,p) retracts into a non-evertable, muscular proboscis sheath (figs.14,15,ps) that extends from just behind the rhyncostome to nearly the rear of the cephalic sinus. It is estimated that the length of the everted proboscis would roughly equal the shell length. The mouth is situated at the tip of the proboscis, with a small buccal mass positioned just behind the buccal cavity. The radular ribbon is short (800 μm) and narrow (75 μm), with about 80 rows of teeth. The rachidian is broad, with 3 conical cusps compressed toward its center. Lateral teeth have a single, scythe-shaped cusp. As the only specimen with a radula

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FIGS. 7-8. Details of shell structure of *Fulgurofusus (Fulgurofusus) brayi.*

7. SEM micrograph of fracture surface. Plane of fracture perpendicular to the outer lip. Scale bar = 100 μm.
8. SEM micrograph of periostracum. Scale bar = 100 μm.

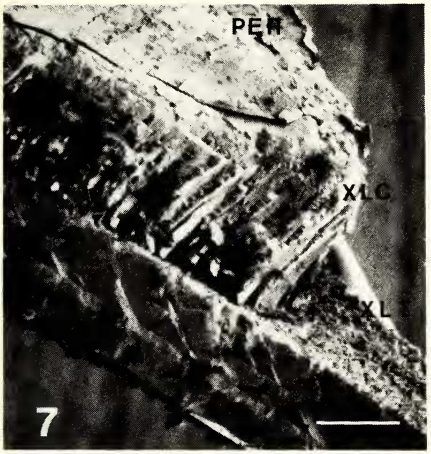
FIG. 9. SEM micrograph of radular ribbon of *Fulgurofusus (Fulgurofusus) bermudezi*, taken from specimen shown in figure 25. Scale bar = 10 μm.

FIG. 10. SEM micrograph of radular ribbon of *Fulgurofusus (Histrocosceptrum) atlantis,* taken from the holotype (figure 32). Scale bar = 10 μm.

FIG. 11. SEM micrograph of radular ribbon of *Columbarium (Columbarium) spinicinctum*, AMNH 180318. Scale bar = 10 μm.

FIG. 12. SEM micrograph of radular ribbon of *Fulgurofusus (Peristarium) aurora*, taken from specimen shown in figure 52. Scale bar = 10 μm.

PER, periostracum; XLC, crossed lamellar aragonite – collabral; XLT, crossed lamellar aragonite – transverse.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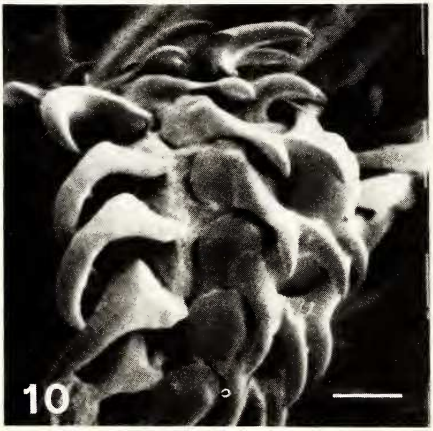
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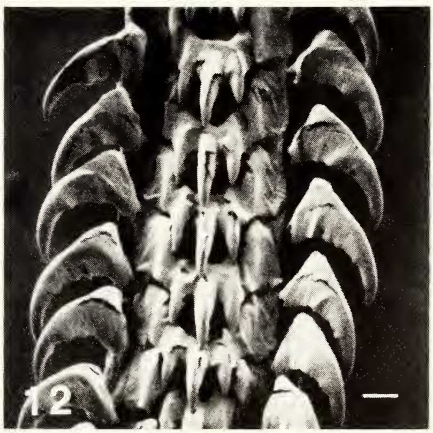
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FIG. 13. Geographic distribution of the western Atlantic species of *Fulgurofusus s.s.*

was serially sectioned, a SEM examination of the radula was not possible. Bayer (1971:172, fig. 39 C) figured the radula of this species. A section through the proboscis just behind the buccal mass (fig.16) reveals that the ducts of the salivary glands (fig.16,dsg) are imbedded beneath the dorsal folds (fig.16,df). A thin layer of transverse muscle (fig.16,tms) separates the esophagus (fig.16,es) from the nerves (fig.16,n) and blood vessel (fig.16,bv) that run the length of the proboscis. From the rear of the proboscis, the esophagus runs anteriorly, enlarging to form the valve of Leiblein (fig.15,vl) before passing through the nerve ring (fig.15,nr). Behind the nerve ring lie 2 large asymmetrical salivary glands (fig.15,sg), the larger right gland situated anterior to the smaller left. The gland of Leiblein (fig.15,gl) lies behind the salivary glands and to the left of and partially under the proboscis sheath. After leaving the cephalic sinus, the esophagus enters the stomach (fig.15,sto), which lies along the dorsal surface of the digestive gland, just behind the kidney. Longitudinal folds run the length of the U-shaped stomach and into the intestine, which expands into a broad, spacious rectum (figs.14,15,r) after entering the mantle cavity. Dorsal to the anterior third of the rectum lies the anal gland (fig.15,ag). The rectum constricts and detaches from the roof of the mantle cavity about 1 mm before terminating in the anus (fig.14,15a).

MALE REPRODUCTIVE SYSTEM: The testis (figs. 14,17,te) is situated along the right side of the digestive gland, just behind the kidney. It consists of a mass of tubules that converge on a testicular duct (fig. 17,td) that runs anteriorly along the right ventral side of the visceral mass. Upon reaching the posterior portion of the kidney, this duct doubles in diameter and becomes convoluted, serving as the seminal vesicle (fig. 17,sv). The anterior portion of the seminal vesicle runs along the pericardium (fig. 17,pc), but no gonopericardial connection could be detected. Anterior to the pericardium, the duct again constricts to form the vas deferens (fig. 17,vd). This non-glandular, closed duct enters the mantle cavity along its right wall, just below the rectum, descending to its floor at midlength, where it becomes a muscular, open groove that runs anteriorly along the mantle cavity and along the inner edge of the broad, flattened penis (figs. 14,17,pen) to its rounded distal end. Prostatic tissue (figs. 18,19,pr) lines this groove along its entire length.

ETYMOLOGY: Named after W. Scott Bray, Captain of the ATLANTIS.

TYPE SPECIMENS: Holotype — MCZ 221601, length 49.1 mm; Paratype — MCZ 221602, length 39.2 mm.

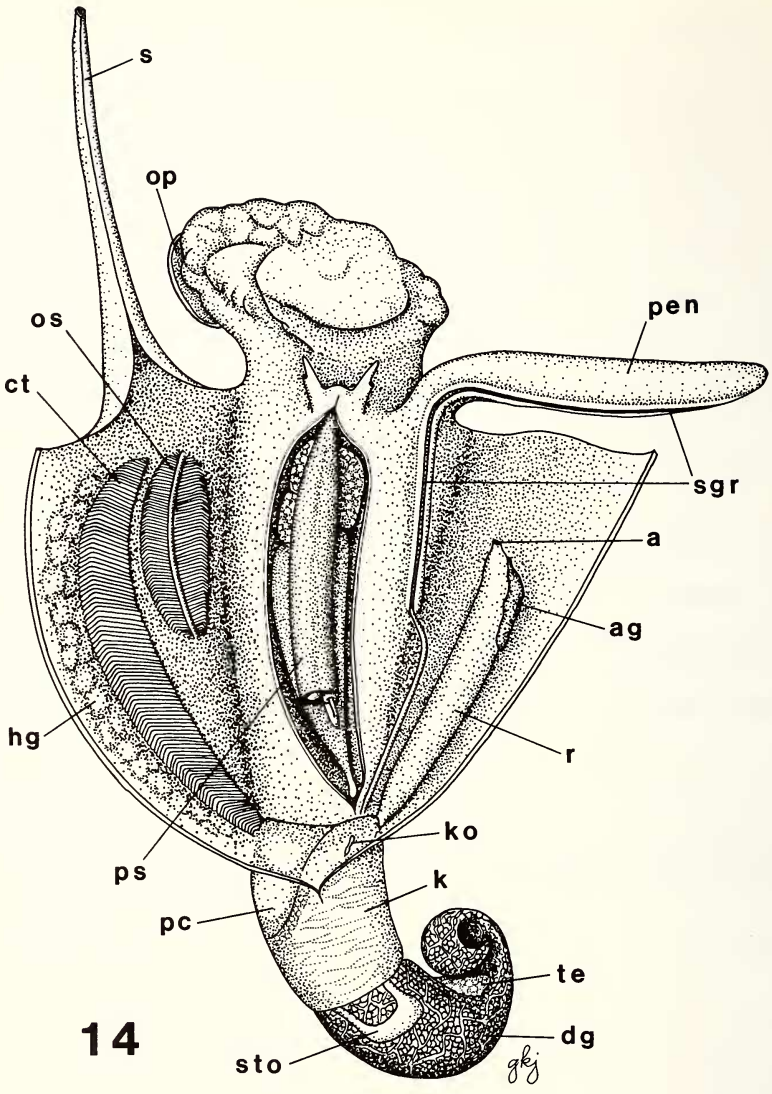
TYPE LOCALITY: Off Cabo Codera, Venezuela, 11°00'N,66°01'W, in 273 m.

GEOGRAPHIC DISTRIBUTION (fig. 13): This is the most widely distributed *Fulgurofusus*. It has been collected off Nevis in the Lesser Antilles and along the southern Caribbean Sea, from eastern Venezuela to Panama.

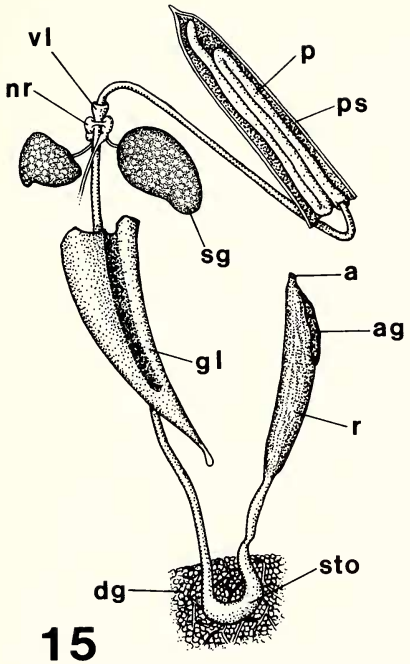
ECOLOGY: *Fulgurofusus brayi* inhabits mud bottoms at depths ranging from 273 to 769 m, with a mean station depth (n = 13) of 444 m. Rectal contents include a large number of polychaete setae attributed to the families Serpulidae and Chaetopteridae by Drs. M.L. Jones and K. Fauchald of the National Museum of Natural History, Smithsonian Institution.

FIGS. 14-19 (following pages). Anatomical features of *Fulgurofusus (Fulgurofusus) brayi.*

14. Male specimen removed from shell and partially uncoiled, with mantle and mantle cavity floor opened by mid-dorsal incisions.
15. Alimentary system.
16. Transverse section through the proboscis behind the buccal mass.
17. Male reproductive system.
18. Transverse section through the anterior vas deferens.
19. Transverse section through the middle of the penis.



a, anus; ag, anal gland; bv, blood vessel; cm, circular muscle; ct, ctenidium; df, dorsal fold; dg, digestive gland; dsg, duct of salivary gland; es, esophagus; gl, gland of Leiblein; hg, hypobranchial gland; k, kidney; ko, kidney opening; lm, longitudinal muscle; mc, mucous cells; n, nerve; nr, nerve ring; op, operculum; os, osphradium; p, proboscis; pc, pericardium; pen, penis; pr, prostate gland; ps, proboscis sheath; r, rectum; rm, retractor muscles; s, siphon; sg, salivary glands; sgr, seminal groove; sto, stomach; sv, seminal vesicle; td, testicular duct; te, testis; tms, transverse muscular sheet; vd, vas deferens; vl, valve of Leiblein.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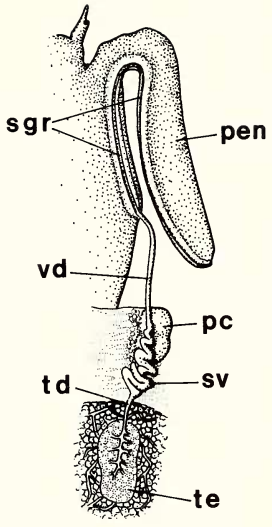
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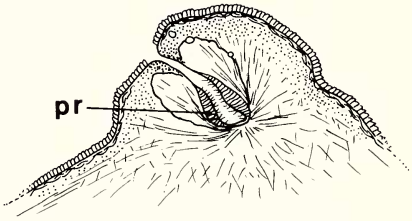
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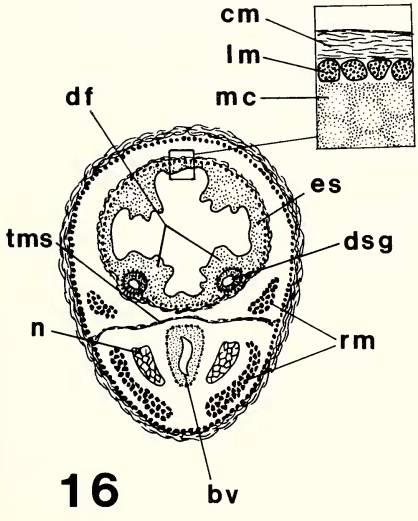
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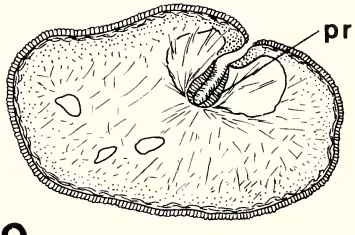
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MATERIAL EXAMINED: OREGON II sta. 24263, Off Nevis, Lesser Antilles, 17°09'N,62°44.8'W, in 512-769 m (IRCZM 65:1806); Dredged off Venezuela, in 342 m (AMNH 187184); Off Venezuela, in 366 m (AMNH 195603); Off Cabo Codera, Venezuela, 11°00'N, 66°01'W, in 273 m (MCZ 221601 — holotype; MCZ 221602 — paratype); PILLSBURY sta. P-340, Off Punto Mosquito, Panama, 9°14'N,77°46'W, in 307-366 m (UMML); PILLSBURY sta. P-374, NW of Golfo de Morrosquillo, Colombia, 9°57'N, 76°11'W, in 439-377 m (UMML); PILLSBURY sta. P-386, Off Cartagena, Colombia, 10°30'N,75°42'W, in 275-357 m (UMML); PILLSBURY sta. P-394, WNW of Golfo de Morrosquillo, Colombia, 9°29'N,76°26'W, in 421-641 m (UMML; USNM 806988); PILLSBURY sta. P-445, ESE of Escudo de Veraguas, Panama, 9°02'N,81°24'W, in 342-346 m (UMML; DMNH 153522); PILLSBURY sta. P-447, Golfo de los Mosquitos, Panama, 9°02'N, 81°07'W, in 664-681 m (UMML); PILLSBURY sta. P-753, Off Venezuela, 11°18.8'N,68°22'W, in 384-607 m (UMML); PILLSBURY sta. P-776, Off eastern Colombia, 12°13.3'N,72°50'W, in 408-576 m (UMML); PILLSBURY sta. P-781, Off eastern Colombia, 11°30.1'N, 73°26.5'W, in 567-531 m (UMML; USNM 806987).

MEASUREMENTS OF SHELL CHARACTERS (n = 10):

	length	width	# whorls	spire angle
mean	41.8 mm	15.3 mm	7.2	69.8°
range	28.5 – 73.0	9.0 – 25.8	6.0 – 8.5	53° – 109°
sd	12.9	4.7	0.7	18.4°

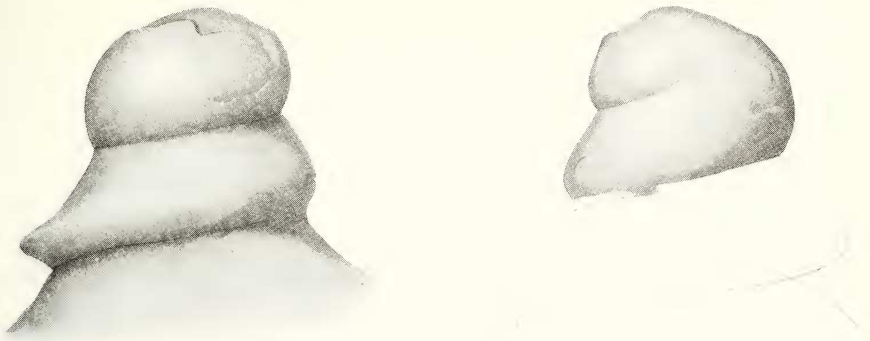
COMPARATIVE REMARKS: Although *F. brayi* is the most variable and widely distributed member of the subgenus, it can readily be distinguished from all other species by its large size, broad spire, prominent peripheral keel and lack of axial sculpture, even in early whorls. Specimens taken off Venezuela tend to be more globose and have thicker shells (figs.1,2), while those from the western Caribbean often have depressed spires (fig.5).

FIG. 20. Protoconch of *Fulgurofusus (Fulgurofusus) brayi* (Clench, 1959). USNM 806988.

FIG. 21. Protoconch of *Fulgurofusus (Fulgurofusus) bermudezi* (Clench and Aguayo, 1938). DMNH 153521.

FIG. 22. Protoconch of *Fulgurofusus (Fulgurofusus) ecphoroides* new species. Holotype (figure 27).

Scale bar = 1 mm for all drawings.



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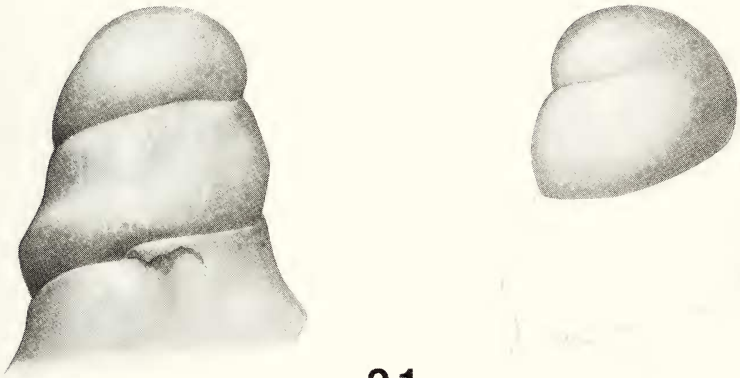

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Fulgurofusus (Fulgurofusus) sarissophorus (Watson, 1882)

Figures 3,13

SYNONYMY

1882 *Fusus (Colus) sarissophorus* Watson, J. Linn. Soc. Lond. 16:382.

1886 *Fusus sarissophorus* Watson, Watson, Challenger Report Zoology 15(2):196-197,pl.14, fig.1.

1944 *Columbarium sarissophorum* (Watson), Clench, Johnsonia 1(15):1-2,pl.1,fig.1; 1975 Rios, Brazilian Marine Mollusks Iconography, p.77,pl.21,sp.313.

1969 *Fulgurofusus sarissophorus* (Watson), Darragh, Proc. Roy. Soc. Vict. 83(1):102,pl.6,figs.107,112.

DESCRIPTION: Shell small (19 mm), thin, fusiform; spire angle 53°; protoconch glassy, bulbous, with 1½ whorls; transition to teleoconch indistinct; teleoconch with 5 convex whorls; suture impressed; peripheral keel rounded in transition zone, extending into a short flange normal to the coiling axis in the first post-nuclear whorl; spiral sculpture of fine threads more prominent anterior to keel; axial sculpture of sinuate growth striae and 16-20 small tubercles per whorl along edge of peripheral keel; aperture strongly ovate; outer lip smooth; inner lip smooth, appressed posteriorly; siphonal canal long, straight, axial; shell and aperture color porcellaneous white; periostracum, operculum, and soft parts unknown.

ETYMOLOGY: Gr. *sarissa* — long pike used by Macedonian foot soldiers + Gr. *phoros* — bearing.

TYPE SPECIMEN: Holotype — BM(NH) 1887.2.9.687, length 19.5 mm.

TYPE LOCALITY: CHALLENGER station 122, Off Pernambuco, Brazil, 9°05'S,34°50'W, in 350 fathoms (640 m).

GEOGRAPHIC DISTRIBUTION (fig. 13): Known only from the type locality.

ECOLOGY: This species has only been collected at one station, at a depth of 640 meters, on a substrate of red clay. The only known specimen has a naticid bore hole.

MATERIAL EXAMINED: The holotype.

MEASUREMENTS OF THE HOLOTYPE:

length	width	# whorls	spire angle
19.5 mm	6.8mm	6.5	53°

COMPARATIVE REMARKS: The unique holotype resembles Venezuelan specimens of *F. brayi* in general shape, but its small size and the presence of tubercles along the peripheral keel serve to distinguish it from that species. It differs from *F. bermudezi* in having a broader spire and finer and more numerous spiral threads.

Fulgurofusus (Fulgurofusus) bermudezi (Clench and Aguayo, 1938)
Figures 9,13,21,23-26

SYNONYMY

1938 *Columbarium bermudezi* Clench and Aguayo, Mem. Soc. Cub. Hist. Nat. 12(5):383-384,pl.28,fig.7; 1944 Clench, Johnsonia 1(15):2,pl.1,fig.3.

1969 *Fulgurofusus bermudezi* (Clench and Aguayo), Darragh, Proc. Roy. Soc. Vict. 83(1):101-102,fig.5,pl.6,figs.120-121.

1971 *Columbarium (Fulgurofusus) bermudezi* Clench and Aguayo, Bayer, Bull. Mar. Sci. 21(1):173,figs. 38 B-D, 39 A; 1974 Abbott, American Seashells, second edition, p.170,fig.1803.

DESCRIPTION — SHELL: Medium in size (to 31 mm), elongate, thin; spire angle 28°-32°; protoconch (fig.21) glassy, bulbous, of 1½ whorls that gradually merge into teleoconch; teleoconch with 7 slightly convex whorls; suture impressed; keel rounded in transition zone, nodulate in early whorls, with nodules fusing by the third post-nuclear whorl to form a crenulated flange that may be normal to the coiling axis (figs.23,24) or directed anteriorly (figs.25,26); growth striae fine, sinuate; spiral sculpture of fine threads to strong cords generally limited to posterior portion of the siphonal canal; aperture ovate; outer lip smooth; inner lip smooth, appressed posteriorly; siphonal canal long, straight, axial; shell and aperture color white; periostracum thin, yellowish.

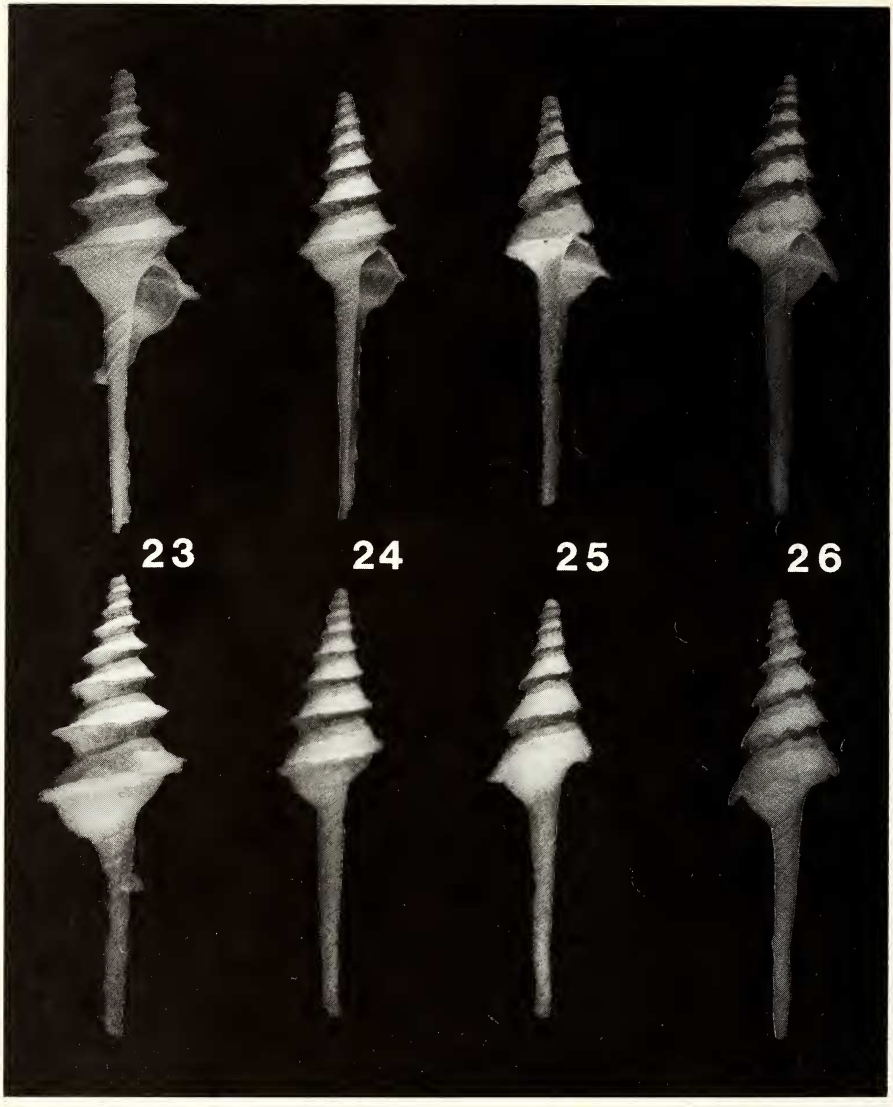
ANIMAL: A single, dried specimen (fig.25) was reconstituted and found to consist of nearly 3 whorls, of which the mantle cavity ocupied 1¼ whorl, the kidney ½ whorl and the digestive gland ¾ whorl. Tentacles short and blunt, with large black eyespots; foot long, narrow, bearing an elongate, corneous, terminally nucleate operculum; mantle cavity proportionally narrower and longer than in *F. brayi*, as were the pallial organs and penis; radular ribbon (fig.9) small, containing 73 rows of teeth; rachidian with 3 conical cusps radiating from the middle half of the tooth; basal plate crescent-shaped, with broadly expanded ends; lateral teeth with a single, long, curved, tapering cusp rising from an elongate basal plate.

ETYMOLOGY: Named after P.J. Bermudez, who studied the foraminifera collected by the ATLANTIS.

TYPE SPECIMENS: Holotype —MCZ 135007, length 27.5 mm; paratype — MCZ 135008, length 25.0 mm; paratype — Museo Poey, Havana, Cuba; paratypes — MCZ 135009 fragments.

TYPE LOCALITY: ATLANTIS station 2989, Off Sagua la Grande, Santa Clara, Cuba, 23°10'N,80°04'W, in 360 fathoms (658 m).

GEOGRAPHIC DISTRIBUTION (fig.13): This species has been reported from the northern coast of Cuba, the Santaren and Northwest Providence Channels, and appears to be restricted to the upper continental slope.



FIGS. 23-26. *Fulgurofusus (Fulgurofusus) bermudezi* (Clench and Aguayo, 1938).

23. USNM 806989, GERDA station G-1018, ENE of Dog Rocks, Santaren Channel, in 556 m (2 X).
24. Holotype, MCZ 135007, ATLANTIS station 2989, Off Sagua la Grande, Santa Clara, Cuba, in 658 m (2 X).
25. USNM 806990, GERDA station G-1015, W of Anguilla Cays, Santaren Channel, in 525-516 m (2 X).
26. USNM 806989, GERDA station G-1018, ENE of Dog Rocks, Santaren Channel, in 556 m (2 X).

ECOLOGY: *Fulgurofusus bermudezi* has a bathymetric range of 384-1006 m, with a mean station depth (n = 17) of 600 m. It has been taken on bottoms ranging from fine sand to mud.

MATERIAL EXAMINED: ATLANTIS sta. 2981 D, Off Punta Alegre, Cuba, 22°48'N,78°51'W, in 347-421 m (MCZ 135049); ATLANTIS sta. 2982 A, Off Punta Alegre, Cuba, 22°48'N,78°50'W, in 384 m (MCZ 135050); ATLANTIS sta. 2988, Off Sagua la Grande, Santa Clara, Cuba, 23°15'N, 79°57'W, in 695 m (MCZ 135008 — paratype); ATLANTIS sta. 2989, Off Sagua la Grande, Santa Clara, Cuba, 23°10'N,80°04'W, in 658 m (MCZ 135007 — holotype, MCZ 135009 — paratypes); ATLANTIS sta. 3422, Off Caibarien, Santa Clara, Cuba, 23°05'N,79°29'W, in 457 m (MCZ 135166); ATLANTIS sta. 3423, Off Caibarien, Santa Clara, Cuba, 23°50'N, 79°08'W, in 448 m (MCZ 135167); ATLANTIS sta. 3424, Off Caibarien, Santa Clara, Cuba, 22°53'N,79°08'W, in 439 m (MCZ 135204); ATLANTIS sta. 3427, Off Caibarien, Santa Clara, Cuba, 22°52'30"N,79°20'W, in 439 m (MCZ 135169); ATLANTIS sta. 3443, Off Sagua la Grande, Santa Clara, Cuba, 23°22'N,79°53'W, in 594 m (MCZ 184514); ATLANTIS sta. 3457, Off Sagua la Grande, Santa Clara, Cuba, 23°23'N, 80°36'W, in 1006 m (MCZ 135168); ATLANTIS sta. 3459, Off Sagua la Grande, Santa Clara, Cuba, 23°21'N,80°36'W, in 914 m (MCZ 135203); ATLANTIS sta. 3475, Off Cardenas, Cuba, 23°18'N,80°48'W, in 732 m (MCZ 135250); GERDA sta. G-190,NW of Great Stirrup Cay, Northwest Providence Channel, 25°57'N, 78°07'W, in 733-897 m (DMNH 153521); GERDA sta. G-524, Northwest Providence Channel, 26°17'N, 78°41'W, in 513-715 m (DMNH 153520); GERDA sta. G-1015, W of Anguilla Cays, Santaren Channel, 23°34'N, 79°17'W, in 525-516 m (UMML; USNM 806990); GERDA sta. G-1017, E of Cay Sal Bank, Santaren Channel, 23°58'N,79°17'W, in 555 m (UMML); GERDA sta. G-1018, ENE of Dog Rocks, Santaren Channel, 24°07'N,79°28'W, in 556 m (UMML; USNM 806989).

MEASUREMENT OF SHELL CHARACTERS (n = 10):

	length	width	# whorls	spire angle
mean	27.5 mm	6.6 mm	8.0	29.2°
range	25.4 – 31.0	5.6 – 8.1	7.5 – 8.75	28° – 32°
sd	1.8	0.8	0.6	1.1°

COMPARATIVE REMARKS: A high spire, axial ribbing on early whorls, and lack of spiral sculpture above the periphery are characters that distinguish this species from other members of the subgenus. It resembles *F. quercollis* in general body shape, but lacks the pronounced spiral sculpture characteristic of the Paleocene species. *Fulgurofusus bermudezi* is quite variable in shell form, the peripheral keel may be narrow or wide, directed laterally or anteriorly,

smooth or crenulated. Unlike *F. brayi*, this cannot be attributed to clinal variation, as extreme examples (figs. 23,26) have been taken at the same station.

Fulgurofusus (Fulgurofusus) ecphoroides new species

Figures 13,22,27-31

DESCRIPTION: Shell small (to 18.5 mm), delicate, fusiform; spire angle 47°-58°; protoconch (fig.22) bulbous, glassy, of 1½ whorls; transition to teleoconch marked by acquisition of a round keel that rapidly develops into a short peripheral flange; teleoconch with 5 convex whorls; suture impressed; spiral sculpture of 2-4 strong cords on body whorl anterior to keel, and 2-6 slightly weaker cords on posterior portion of siphonal canal; keel and cords undulating, furrowed, each consisting of 2 fine threads in close apposition; axial sculpture limited to fine, sinuate growth striae; aperture ovate; outer lip furrowed beneath spiral cords; inner lip smooth, may be posteriorly appressed or form a raised peristomal plate; siphonal canal long, axial, twisted slightly; color uniform porcellaneous white; periostracum, operculum, and soft parts unknown.

ETYMOLOGY: Named for its resemblance to shells of the genus *Ecphora* Conrad, 1843 (Gastropoda: Thaididae). *Ecphora* + Gr. *oides* — like.

TYPE SPECIMENS: Holotype — USNM 810464, length 18.4 mm; Paratype 1 — DMNH 153515, length 16.0 mm; Paratype 2 — MCZ 281476, length 10.3 mm; Paratype 3 — USNM 821507, length 14.1 mm; 15 additional paratypes — USNM 821507.

TYPE LOCALITY: OREGON station 4226, 180 miles NE of Tijoca, Pará, Brazil, 0°18'N, 44°17'W, in 150 fathoms (274 m).

GEOGRAPHIC DISTRIBUTION (fig. 13): Known only from the type locality.

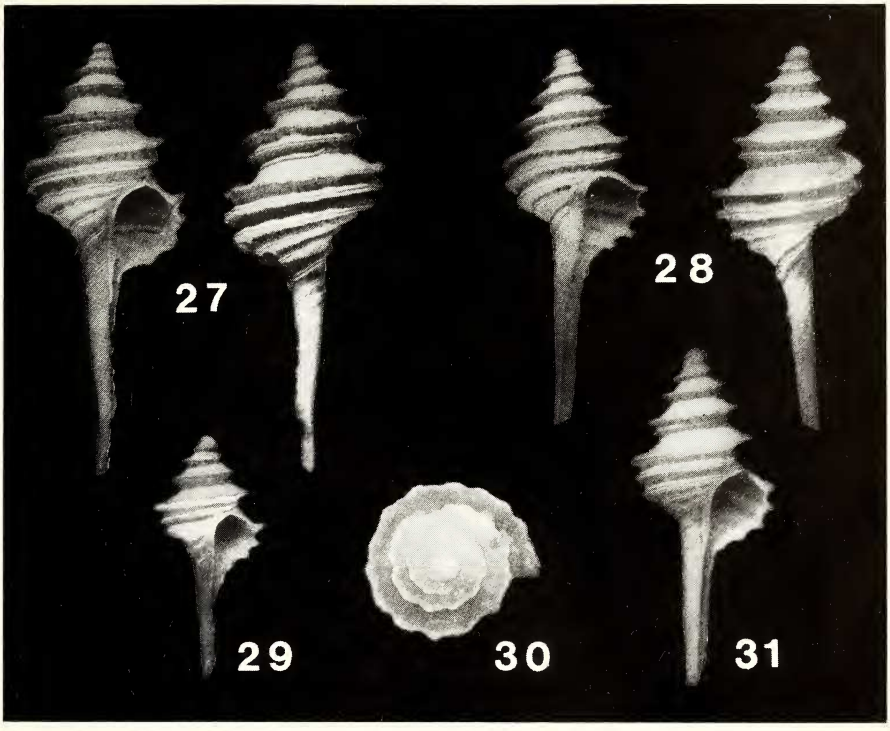
ECOLOGY: Of the 19 specimens collected at a depth of 274 m, none were taken alive. Several were inhabited by hermit crabs, and a number had been drilled by naticids.

MATERIAL EXAMINED: The 19 specimens in the type lot.

MEASUREMENTS OF SHELL CHARACTERS (n = 10):

	length	width	# whorls	spire angle
mean	14.0 mm	5.9 mm	5.6	52.6°
range	10.3-18.4	3.9-7.7	4.5-7.0	47°-58°
sd	2.3	1.0	0.3	3.6°

COMPARATIVE REMARKS: This distinctive new species can be distinguished from all other members of the subgenus by the presence of 2-4 strong cords on the body whorl and by the incised furrows that run along the peripheral keel and all spiral cords. The inner lip may form a raised peristomal plate in mature



FIGS. 27-31. *Fulgurofusus (Fulgurofusus) ecphoroides* new species.

27. Holotype, USNM 810464, OREGON station 4226, 180 miles NE of Tijoca, Pará, Brazil, in 274 m (3 X).
28. Paratype 1, DMNH 153515, OREGON station 4226, 180 miles NE of Tijoca, Pará, Brazil, in 274 m (3 X).
29. Paratype 2, MCZ 281476, OREGON station 4226, 180 miles NE of Tijoca, Pará, Brazil, in 274 m (3 X).
30. Apical view of paratype 2 (5 X).
31. Paratype 3, USNM 821507, OREGON station 4226, 180 miles NE of Tijoca, Pará, Brazil, in 274 m (3 X).

specimens (figs.27,31). Darragh (1969:69,71) considered such a plate to be characteristic of the genus *Columbarium*, but the absence of other *Columbarium* characters such as spines on the periphery, scales on spiral cords and a strong anterior carina, as well as the presence of a *Fulgurofusus* protoconch and early whorls support the placement of this species in *Fulgurofusus*.

This species most closely resembles *F. sarissophorus*, with which it agrees in size and general shape, but from which it differs in having an incised keel and spiral cords.

Subgenus *Histricosceptrum* Darragh, 1969

SYNONYMY

1969 *Histricosceptrum* Darragh, Proc. Roy. Soc. Vict. 83(1):87. Type species by original designation: *Columbarium atlantis* Clench and Aguayo, 1938.

1971 *Columbarium (Histricosceptrum)* Darragh, Bayer, Bull. Mar. Sci. 21(1):170.

This group, which is not represented in the fossil record, is very similar to, and clearly derived from, *Fulgurofusus*. It is characterized by a relatively thick shell with strong spiral cords along the body whorl and siphonal canal as well as by the formation of long, open spines along the periphery. In addition to 3 western Atlantic species, one of which is described herein, a species from the Indian Ocean has been provisionally included by Darragh (1969:89) who stated that "further work . . . may show that it would be better placed in *Columbarium*".

Fulgurofusus (Histricosceptrum) atlantis (Clench and Auguayo, 1938)
Figures 10,32,38,39

SYNONYMY

1938 *Columbarium atlantis* Clench and Aguayo, Mem. Soc. Cub. Hist. Nat. 12(5):382-383,pl.28,fig.1; 1944 Clench, Johnsonia 1(15): 2-3,pl.1,fig.4.

1969 *Histricosceptrum atlantis* (Clench and Aguayo), Darragh, Proc. Roy. Soc. Vict. 83(1):88,fig.1,pl.6,figs.119,122.

1974 *Columbarium (Histricosceptrum) atlantis* Clench and Aguayo Abbott, American Seashells, second edition, p.170,fig.1802.

DESCRIPTION — SHELL: Of medium size (to 36 mm), elongate, moderately heavy; spire angle 30°-32°; protoconch (fig.39) of 1½ whorls, glassy, rotund; transition to teleoconch indistinct, marked by gradual acquisition of a peripheral keel, rounded at first, but with spines by second postnuclear whorl; teleoconch with 7 convex whorls; suture impressed; keel with 8-10 long, open, anteriorly deflected spines per whorl; spiral sculpture of 4-6 threads and 1 cord between suture and keel, 3-5 cords on body whorl anterior to keel and 20-25 cords on posterior ⅔ of siphonal canal; growth striae fine, sinuate; aperture semicircular; outer lip furrowed beneath keel; inner lip smooth, covered with thin glaze; siphonal canal long, stout, straight; color uniformly white; periostracum unknown.

ANIMAL: Foot long, narrow, bearing a thin, yellow corneous, strongly ovate operculum with a terminal nucleus and circular attachment area; tentacles short, with large black eyes; mantle cavity narrow, long of 1¼ whorls; penis with open, glandular groove; proboscis long, coiled in proboscis sheath; radula (fig.10) tiny, consisting of approximately 85 rows; rachidian with 3 cusps,

long, conical, recurved; central cusp flanked by slightly shorter cusps; ends of basal plate expanded; lateral teeth with long, single, scythe-like cusps.

ETYMOLOGY: Named after the research vessel ATLANTIS, which collected the only known specimens.

TYPE SPECIMENS: Holotype — MCZ 135004, length 35.2 mm; paratype — Museo Poey, Havana, Cuba.

TYPE LOCALITY: ATLANTIS station 2999, Off Matanzas, Cuba, 23°10'N, 81°29'W, in 421 fathoms (770 m).

GEOGRAPHIC DISTRIBUTION (fig. 38): This species has been reported from 4 stations off the northwest coast of Cuba. All are within 150 miles (250 km) of the type locality.

ECOLOGY: This species has been taken at depths ranging from 475 to 770 meters with an average station depth (n = 4) of 650 meters. It has been collected with *F. bermudezi* at 2 stations.

MATERIAL EXAMINED: ATLANTIS sta. 2999, Off Matanzas, Cuba, 23°10'N, 81°29'W, in 770 m (MCZ 135004 — holotype); ATLANTIS sta. 3434, Off Sagua la Grande, Santa Clara, Cuba (MCZ 178190).

MEASUREMENTS OF SHELL CHARACTERS (n = 2):

length	width	# whorls	spire angle
34.0-35.2 mm	6.3-7.1 mm	8.5	30°-32°

COMPARATIVE REMARKS: This species may be distinguished from its congeners by its thin elongate shell, with spiral sculpture limited to fine, simple threads, and by the presence of a single row of long, open, anteriorly directed spines along the periphery.

Fulgurofusus (Histricosceptrum) bartletti (Clench and Aguayo, 1940)
Figures 33-34,38

SYNONYMY

1940 *Columbarium bartletti* Clench and Aguayo, Mem. Soc. Cub. Nat. Hist. 14(1):86,pl.14,fig.3; 1944 Clench, Johnsonia 1(15):3-4, pl.1,fig.5.

1969 *Histricosceptrum bartletti* (Clench and Aguayo), Darragh, Proc. Roy. Soc. Vict. 83(1):88-89.

1971 *Columbarium (Histricosceptrum) bartletti* Clench and Aguayo, Bayer, Bull. Mar. Sci. 21(1):170,fig.38 A; 1974 Abbott, American Seashells, second edition, p.170,fig.1801.

DESCRIPTION: Shell of medium size (to 39 mm), elongate, heavy; spire angle 31°-34°; protoconch glassy, bulbous, of 1½ whorls; transition to teleoconch indistinct; keel, rounded at first, becomes nodular, then, by second post-

nuclear whorl, spinose; spines long, open, normal to coiling axis, numbering 7-8 per whorl; teleoconch of 8 convex whorls; suture adpressed; spiral cords between suture and keel becoming more pronounced, fusing by fourth post-nuclear whorl to form a channel at the suture; below keel there are 5 cords on body whorl and 19-23 on posterior half of siphonal canal; growth striae fine, sinuate, forming axial ribs on sutural channel; aperture ovate to subquadrate; outer lip furrowed beneath keel; inner lip smooth, appressed posteriorly; siphonal canal long, stout, axial; color white; periostracum very thin, amber in color; operculum and soft parts unknown.

ETYMOLOGY: Named in honor of Commander J.R. Bartlett, U.S.N., of the U.S. Coast Survey Steamer BLAKE.

TYPE SPECIMENS: Holotype — MCZ 104729, length 38.7 mm; paratype — Museo Poey, Havana, Cuba.

TYPE LOCALITY: BLAKE station 9, Off Homers Cove, Westmoreland, Jamaica, 18°12'N,78°20'W, in 254 fathoms (465 m).

GEOGRAPHIC DISTRIBUTION (fig.38): The two records of this species are from off the southwest coast of Jamaica.

ECOLOGY: Based on two records, the bathymetric range of this species is 465-546 m.

MATERIAL EXAMINED: BLAKE sta. 9, Off Homers Cove, Westmoreland, Jamaica, 18°12'N,78°20'W, in 465 m (MCZ 104729 — holotype); PILLSBURY sta. P-1225, SW of Jamaica, 17°42.5'N,78°58'W, in 546-528 m (USNM 806991).

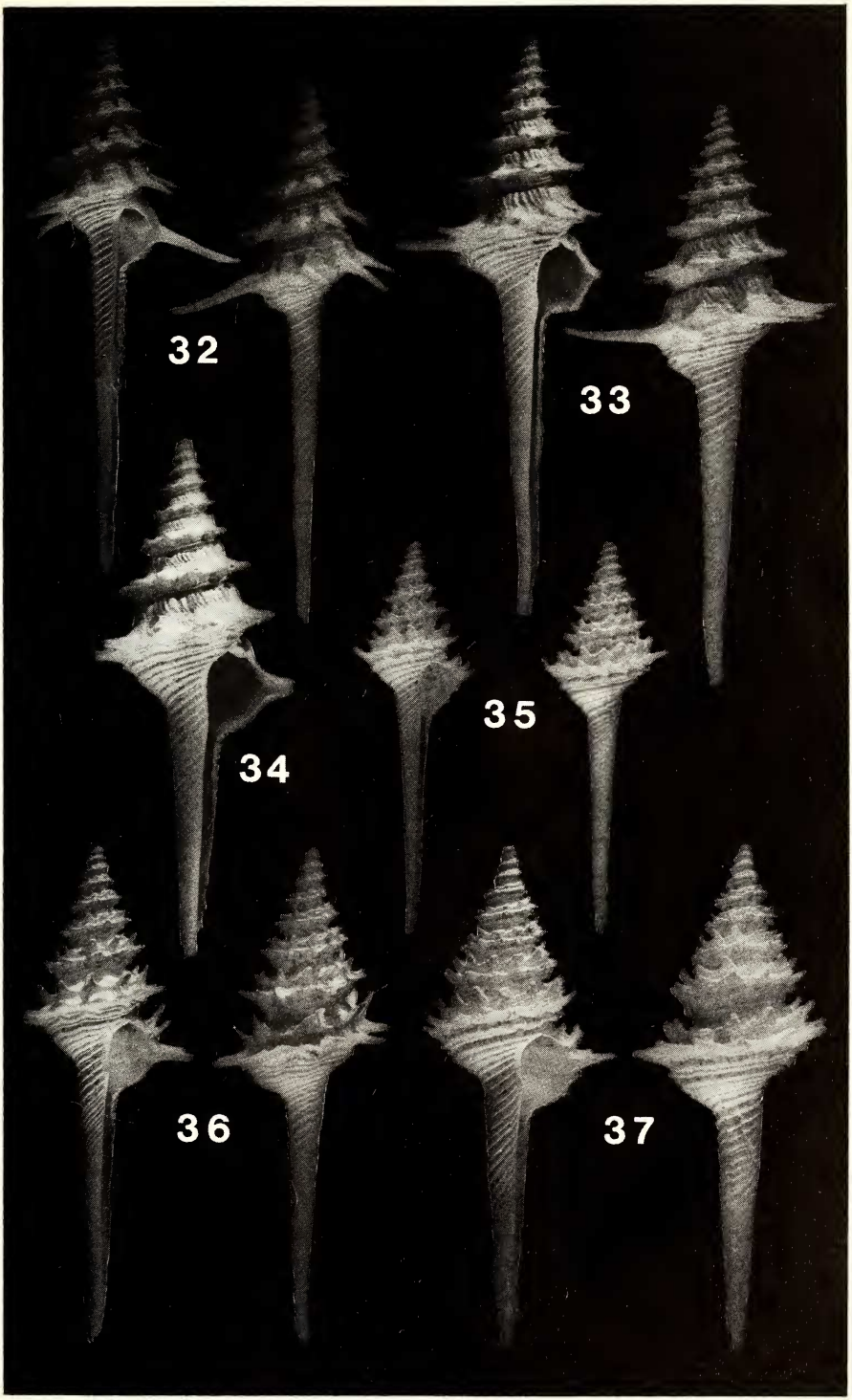
FIG. 32. *Fulgurofusus (Histricosceptrum) atlantis* (Clench and Aguayo, 1938). Holotype, MCZ 135004, ATLANTIS station 2999, Off Matanzas, Cuba, in 770 m (2 X).

FIGS. 33-34. *Fulgurofusus (Histricosceptrum) bartletti* (Clench and Aguayo, 1940).

33. Holotype, MCZ 104729, BLAKE station 9, Off Homers Cove, Westmoreland, Jamaica, in 465 m (2 X).
34. USNM 806991, PILLSBURY station P-1225, SW of Jamaica, in 546-528 m (2X).

FIGS. 35-37. *Fulgurofusus (Histricosceptrum) xenismatis* new species.

35. Holotype, USNM 806992, PILLSBURY station P-1354, Off northeastern Nicaragua, in 192-263 m (2 X).
36. Paratype 1, DMNH 153523, PILLSBURY station P-1354, Off northeastern Nicaragua, in 192-263 m (2 X).
37. Paratype 2, USNM 806993, PILLSBURY station P-1354, Off northeastern Nicaragua, in 192-263 m (2 X).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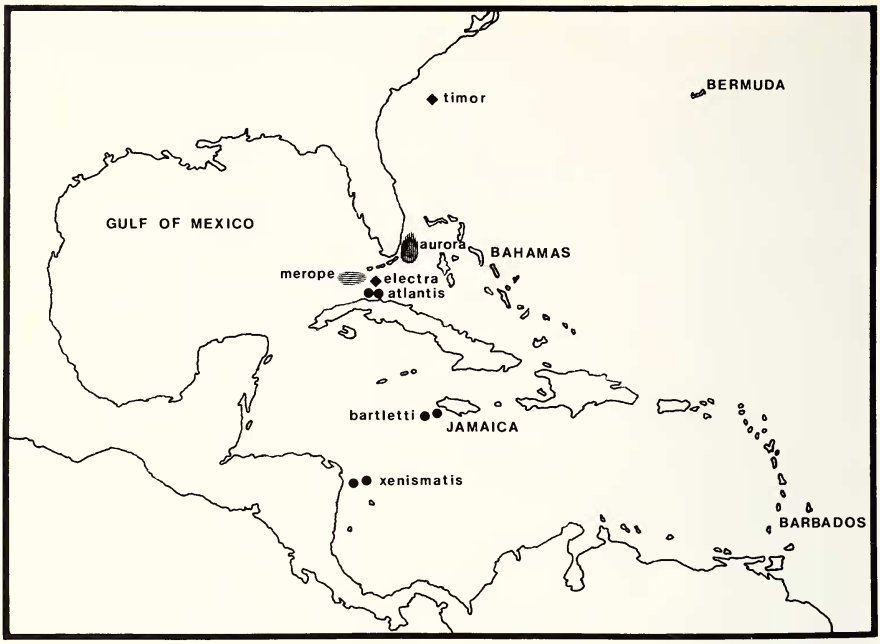


FIG. 38. Geographic distribution of the western Atlantic species of *Fulgurofusus (Histricosceptrum)* and *Fulgurofusus (Peristarium).*

MEASUREMENTS OF SHELL CHARACTERS (n = 2):

length	width	# whorls	spire angle
38.7 mm	8.6-8.8 mm	8.5-9.5	31°-34°

COMPARATIVE REMARKS: The high spire, thick shell, single row of long, heavy, laterally directed spines along the periphery, and strongly channeled suture serve to distinguish this species from all other members of the subgenus.

Fulgurofusus (Histricosceptrum) xenismatis new species

Figures 35-38,40

DESCRIPTION: Shell of medium size (to 34 mm), elongate, thin to moderately heavy; spire angle 32°-40°; protoconch (fig.40) of 1½ whorls, bulbous, glassy; transition to teleoconch indistinct; keel rounded, becoming nodulose and finally spinose by the second post-nuclear whorl; periphery with 10-12 short, open spines per whorl that are directed posteriorly on early whorls, but may be laterally or even anteriorly deflected on final whorl; spiral cord between suture and periphery becomes strongly nodulose, and by the fourth post-nuclear whorl, spinose, producing a second row of spines that are directed posteriorly; teleoconch with 8 convex whorls; suture impressed; spiral sculpture of 4-5

cords on body whorl and 15-20 on posterior ⅔ of siphonal canal; axial growth striae fine; aperture ovate; outer lip furrowed beneath both rows of spines; inner lip smooth, appressed posteriorly; siphonal canal long, stout, axial; color porcellaneous white; periostracum very thin, yellowish; operculum corneous, yellowish, strongly ovate, with terminal nucleus; soft parts unknown.

ETYMOLOGY: Gr. *xenismatis* — amazing.

TYPE SPECIMENS: Holotype — USNM 806992, length 25.8 mm; Paratype 1 — DMNH 153523, length 33.0 mm; Paratype 2 — USNM 806993, length 33.5 mm; Paratype 3 — MCZ 281478, length 27.3 mm; Paratypes 4 & 5 — UMML 30-8301.

TYPE LOCALITY: PILLSBURY station P-1354, Off northeastern Nicaragua, 14°21'N,81°55'W, in 192-263 m.

GEOGRAPHIC DISTRIBUTION (fig.38): This species has only been taken at two stations, both off the northeastern coast of Nicaragua.

ECOLOGY: The shallowest verifiable record for this species is 263 m, the deepest 450 m. Several specimens have muricid and naticid bore holes.

MATERIAL EXAMINED: The 5 specimens in the type lot. Holotype and paratypes 1-3 from the type locality, paratypes 4-5 from PILLSBURY sta. P-1357, Off northeastern Nicaragua, 14°35N, 81°32'W, in 450-576 m.

MEASUREMENTS OF SHELL CHARACTERS (n = 3):

	length	width	# whorls	spire angle
mean	30.8 mm	7.9 mm	8.5	36.8
range	25.8-33.5	6.3-9.4	7.5-9.5	32°-40°

COMPARATIVE REMARKS: A second row of short, open, posteriorly directed spines between the suture and the periphery serves to separate this new species from the other members of the subgenus.

Subgenus *Peristarium* Bayer, 1971

SYNONYMY

1971 *Columbarium (Peristarium)* Bayer, Bull. Mar. Sci. 21(1):176. Type species by original designation: *Columbarium (Peristarium) electra* Bayer, 1971.

Recognizing only the genus *Columbarium*, Bayer (1971) included in it his new subgenus *Peristarium*. Reasons for reelevating *Fulgurofusus* to generic level have already been discussed. *Peristarium* is provisionally regarded as a subgenus of *Fulgurofusus* on the basis of general similarity in shell shape and protoconch, prominence of axial sculpture, and total lack of spines or scales. Known from 4 Recent species, one of which is described herein, the subgenus is characterized by an elongate, moderately heavy shell with spiral ornament

of fine threads to low, broad cords, an incised furrow along the periphery, and 12-16 low axial ribs. The siphonal canal may be dorsally deflected in some species. Gross anatomy is similar to that of *Fulgurofusus* s.s., but the radula differs in having the basal plate of the rachidian even more expanded and buttressed. Unlike most Columbarines, species of *Peristarium* are stenobathic, and do not overlap in their bathymetric ranges.

Fulgurofusus (Peristarium) electra (Bayer, 1971)

Figures 38,41,43-45

SYNONYMY

1971 *Columbarium (Peristarium) electra* Bayer, Bull, Mar. Sci. 21(1): 176-178,figs.39 D,41; 1974 Abbott, American Seashells, second edition, p.170.

DESCRIPTION: Shell small (to 27 mm), elongate, thin; spire angle 26°-28°; protoconch of 1½ whorls glassy, bulbous, not clearly delimited from teleoconch of 8 convex whorls; suture adpressed, shoulder rounded at first, becoming more angulate and bearing nodules within first postnuclear whorl; periphery of shell slightly furrowed, indicating vestiges of 2 spiral cords in close apposition; spiral sculpture of 6-14 weak, broad cords above periphery and 4-5 stronger cords below; siphonal canal with 7-10 weak cords on posterior ⅔; axial sculpture of 14 low ribs per whorl; growth striae fine, sinuate; aperture strongly ovate; outer lip smooth; inner lip smooth, covered with thin glaze; siphonal canal long, stout, axial; color porcellaneous white; periostracum unknown; operculum strongly ovate, corneous, with terminal nucleus and elliptical attachment area; radula (Bayer, 1971,p.172,fig. 39 D) has tricusped rachidian with strongly recurved basal plate and long, single-cusped, recurved lateral teeth.

ETYMOLOGY: Gr. *Electra* — daughter of Agamemnon.

TYPE SPECIMENS: Holotype — USNM 701151, length 26.8 mm; paratype — DMNH 153517; paratypes — UMML.

TYPE LOCALITY: GERDA station G-289, SSE of Key West, Straits of Florida, 24°11'N,81°36'W, in 604-594 m.

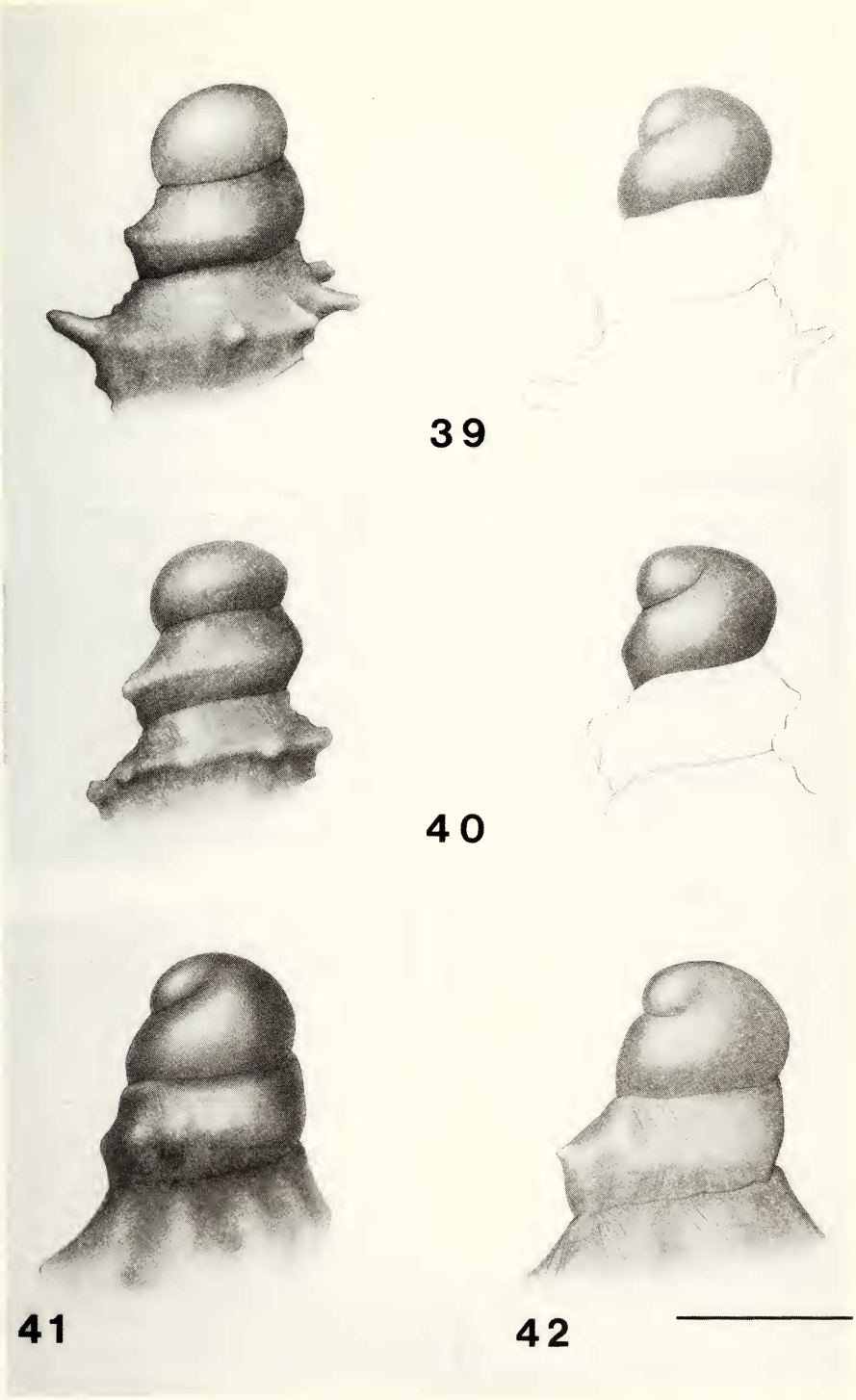
FIG. 39. Protoconch of *Fulgurofusus (Histricosceptrum) atlantis* (Clench and Aguayo, 1938). Holotype (figure 32).

FIG. 40. Protoconch of *Fulgurofusus (Histricosceptrum) xenismatis* new species. Holotype (figure 35).

FIG. 41. Protoconch of *Fulgurofusus (Peristarium) electra* (Bayer, 1971). DMNH 153517.

FIG. 42. Protoconch of *Fulgurofusus (Peristarium) aurora* (Bayer, 1971), specimen shown in figure 51.

Scale bar = 1 mm for all drawings.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GEOGRAPHIC DISTRIBUTION (fig. 38): Known only from the type locality.

ECOLOGY: All known specimens were collected at one station at a depth of 604-594 m.

MATERIAL EXAMINED: The 6 specimens in the type lot.

MEASUREMENTS OF SHELL CHARACTERS (n = 3):

	length	width	# whorls	spire angle
mean	20.0 mm	4.8 mm	7.2	27°
range	16.6-26.8	4.0-6.4	6.5-8.5	26.5°-27.5°

COMPARATIVE REMARKS: This species may be distinguished from other members of the subgenus by its small size, angulate periphery, and numerous fine spiral threads.

Fulgurofusus (Peristarium) merope (Bayer, 1971)

Figures 38,53-55

SYNONYMY

1971 *Columbarium (Peristarium) merope* Bayer, Bull. Mar. Sci. 21(1): 178-180, figs. 39 C,42,43 A; 1974 Abbott, American Seashells, second edition, p.171.

DESCRIPTION: Shell of medium size (to 36 mm), elongate, moderately thin; spire angle 28°-32°; protoconch of nearly 2 whorls, bulbous, glassy; transition to teleoconch indistinct; teleoconch with 8 convex, weakly shouldered whorls; suture adpressed; periphery passes through rounded and angulate stages to become nodulose by the second post-nuclear whorl; spiral sculpture of 4-5 cords above periphery, 2 prominent cords separated by a narrow furrow along the periphery, and 8-10 cords below the periphery, with 20-24 weaker cords along the siphonal canal; axial sculpture of 12 low ribs per whorl; growth striae

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FIGS. 43-45. *Fulgurofusus (Peristarium) electra* (Bayer, 1971).

43. Holotype, USNM 701151, GERDA station G-289, SSE of Key West, Straits of Florida, in 604-594 m (3 X).

44-45. Paratypes, UMML, GERDA station G-289, SSE of Key West, Straits of Florida, in 604-594 m (3 X).

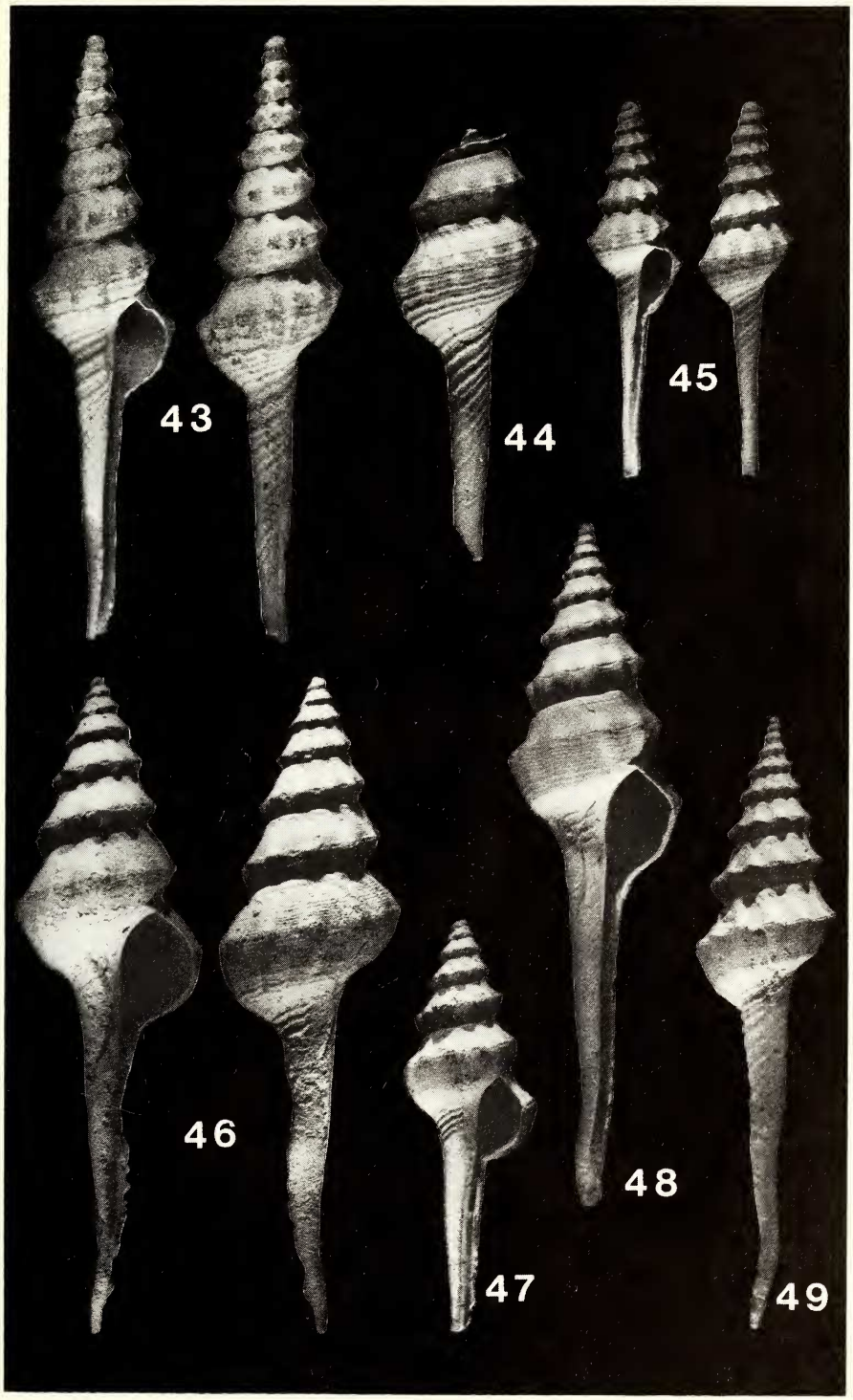
FIGS. 46-49. *Fulgurofusus (Peristarium) timor* new species.

46. Holotype, USNM 87487, ALBATROSS station 2676, Off Cape Fear, North Carolina, in 744 m (1.5 X).

47. Paratype 1, USNM 821508, ALBATROSS station 2676, Off Cape Fear, North Carolina, in 744 m (1.5 X).

48. Paratype 2, Staples collection, Off Cape Fear, North Carolina, in 700 m (2.0 X).

49. Paratype 2, DMNH 153516, Off North Carolina, deep water (1.5 X).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fine, sinuate; aperture ovate; outer lip crenulated in juveniles, smooth in adults; inner lip smooth, covered with thin glaze; siphonal canal long, stout, straight; shell and aperture porcellaneous white in color; periostracum thin, yellowish, forming short lamellae along growth lines; operculum corneous, elongate, slightly unguiculate, with terminal nucleus and small elliptical attachment area; radula (Bayer 1971,p.172,fig.39 C) with a rachidian in which the basal plate is not nearly as recurved as in other members of the subgenus, three cusps occupy a wider portion of the tooth, and lateral teeth appear thinner and more recurved than in other species.

ETYMOLOGY: Gr. *Merope* — one of the Pleiades.

TYPE SPECIMENS: Holotype — USNM 701152, length 36.0 mm; paratype — USNM 806994; paratype — MCZ 281477; paratype — DMNH 156518; paratypes — UMML 30-6970.

TYPE LOCALITY: GERDA station G-476, SW of Marquesas Keys, Straits of Florida, 24°14'N,82°24'W, in 549-512 m.

GEOGRAPHIC DISTRIBUTION (fig. 38): *Fulgurofusus merope* lives along the upper continental slope in the area south of the Marquesas Keys.

ECOLOGY: This species has been taken in depths between 512 and 584 m, with a mean station depth (n = 5) of 546 m.

MATERIAL EXAMINED: GERDA sta. G-970, SW of Marquesas Keys, Straits of Florida, 24°24'N,82°08'W, in 512 m (DMNH 156518); GERDA sta. G-440, SW of Marquesas Keys, Straits of Florida, 24°14'N,82°21'W, in 549-567 m (USNM 806994); GERDA sta. G-966, SW of Marquesas Keys, Straits of Florida, 24°10'N,82°22'W, in 553-558 m (MCZ 281477); GERDA sta. G-476, SW of Marquesas Keys, Straits of Florida, 24°14'N,82°24'W, in 512-549 m (USNM 701152 — holotype); GERDA sta. G-439, SW of Marquesas Keys, Straits of Florida, 24°14'N,82°29'W, in 566-584 m (UMML 30-6970).

MEASUREMENTS OF SHELL CHARACTERS (n = 4):

	length	width	# whorls	spire angle
mean	28.9 mm	7.6 mm	8.6	29.5°
range	22.1-36.0	5.8-9.7	8.0-9.0	28°-30°
sd	6.2	1.5	0.4	0.9°

COMPARATIVE REMARKS: This species may be separated from *Fulgurofusus electra* and *F. timor* by its stronger spiral sculpture and more prominent axial ribs. It differs from *F. aurora* in having an angular periphery and a more constricted juncture between body whorl and siphonal canal.

Fulgurofusus (Peristarium) aurora (Bayer, 1971)

Figures 12,38,42,50-52

SYNONYMY

1971 *Columbarium (Peristarium) aurora* Bayer, Bull. Mar. Sci. 21(1): 180-183,figs.39 E, 43 B, 44; 1974 Abbott, American Seashells, second edition, p.171.

DESCRIPTION — SHELL: Large (to 43 mm), elongate, moderately heavy; spire angle 33°-37°; protoconch (fig.42) of 1½ whorls, glassy, bulbous; transition to teleoconch marked by appearance of rounded keel, which becomes angulate and intersected by axial ribs within the first post-nuclear whorl; teleoconch of 8 convex whorls; suture adpressed; spiral sculpture of low, broad bands separated by narrow furrows; 2 bands, wider than the rest, occur along the rounded periphery, with 4-6 narrower bands above and 7-10 below on body whorl; siphonal canal long, stout, tapering gradually, with up to 25 cords of varying width along most of its length; axial sculpture of 12-16 low ribs; growth striae fine, sinuate; aperture ovate to nearly elliptical; outer lip smooth; inner lip smooth, covered with thin glaze; shell dingy white in color; periostracum thin, yellowish, with axial lamellae that tend to be abraded along spiral cords.

ANIMAL: Reconstituted soft parts, removed from a paratype (fig.52), of about 2⅓ whorls, with the mantle cavity extending over ¾ whorl, the kidney over ½ whorl, and the digestive gland over ¾ whorl; operculum lenticular, amber colored, terminally nucleated; mantle cavity containing a broadly expanded rectum, a muscular open sperm groove, and a long, flat, distally rounded penis, with an open groove running along its inner edge; proboscis, long, folded, containing small buccal mass; radular ribbon (fig.12) small, containing nearly 100 rows of teeth; rachidian with 3 parallel, conical cusps occupying middle half of tooth; ends of basal plate greatly expanded and buttressed in opposition to the cusps; lateral teeth with a single, long, scythe-like cusp.

ETYMOLOGY: L. *Aurora* — goddess of the dawn.

TYPE SPECIMENS: Holotype — USNM 701222, length 41.4 mm; paratypes — USNM 701153; USNM 806995; USNM 806996; DMNH 153519; MCZ 281479; UMML.

TYPE LOCALITY: PILLSBURY station P-1309, NE of Fowey Light, Straits of Florida, 25°40'N, 80°02'W, in 247 m.

GEOGRAPHIC DISTRIBUTION (fig.38): This species inhabits the uppermost continental slope off Miami, Florida.

ECOLOGY: The bathymetric range of *F. aurora* is 247-403 m, with a mean station depth (n = 5) of 339 m. A dorsally deflected siphonal canal indicates an infaunal habitat.

MATERIAL EXAMINED: GERDA sta. G-62, SE of Fowey Light, Straits of Florida, 25°30.5'N,80°00'W, in 384-403 m (USNM 701153); GERDA sta.

G-66, SE of Fowey Light, Straits of Florida, 25°25.5'N,79°59'W, in 366 m (UMML); GERDA sta. G-67, SE of Fowey Light, Straits of Florida, 25°31'N,79°57'W, in 351 m (USNM 806995); GERDA sta. G-828, E of Fowey Light, Straits of Florida, 25°34'N,79°57'W, in 333-340 m (USNM 806996); PILLSBURY sta. P-1309, NE of Fowey Light, Straits of Florida, 25°40'N,80°02'W, in 247 m (USNM 701222 — holotype; DMNH 153519; MCZ 281479).

MEASUREMENTS OF SHELL CHARACTERS (n = 7):

	length	width	# whorls	spire angle
mean	33.4 mm	8.4 mm	7.8	33.2°
range	22.4-43.0	6.1-11.3	7.0-9.0	31°-35°
sd	7.3	1.9	0.7	1.6°

COMPARATIVE REMARKS: *Fulgurofusus aurora* may be distinguished from its congeners by its thick shell and prominent axial ribs and spiral cords, as well as by its rounded shoulder and broad siphonal canal.

Fulgurofusus (Peristarium) timor new species

Figures 38,46-49

SYNONYMY

1889 *Fusus schrammi* Crosse, Dall, Bull. Mus. Comp. Zool. Harvard 18:168; 1889 Dall, Bull. U.S. Natl. Mus. 37:112, 1904 Grabau [in part], Smithson. Misc. Collns. 44:72-73; 1934 Johnson, Proc.Bost.Soc.Nat.Hist., 40(1):128. [not *Fusus schrammi* Crosse, 1865].

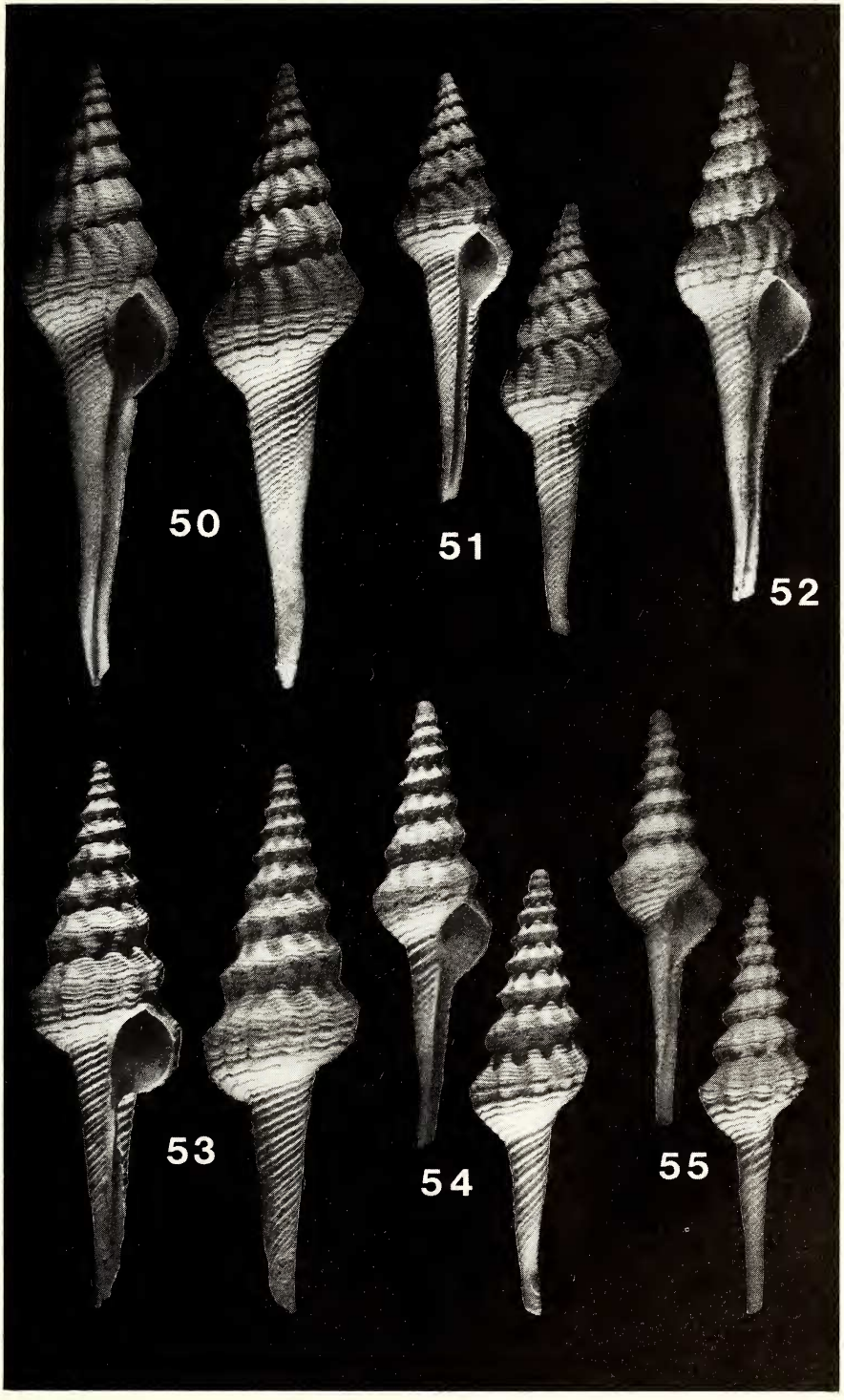
1974 *Fusinus schrammi* (Crosse) Abbott, American Seashells, second edition, p.230 [not *Fusus schrammi* Crosse, 1865].

FIGS. 50-52. *Fulgurofusus (Peristarium) aurora* (Bayer, 1971).

50. Holotype, USNM 701222, PILLSBURY station P-1309, NE of Fowey Light, Straits of Florida, in 247 m (2 X).
51. Paratype, USNM 806996, GERDA station G-828, E of Fowey Light, Straits of Florida, in 333-340 m (2 X).
52. Paratype, MCZ 281479, PILLSBURY station P-1309, NE of Fowey Light, Straits of Florida, in 247 m (2 X).

FIGS. 53-55. *Fulgurofusus (Peristarium) merope* (Bayer, 1971).

53. Holotype, USNM 701152, GERDA station G-476, SW of Marquesas Keys, Straits of Florida, in 549-512 m (2 X).
54. Paratype, DMNH 153518, GERDA station G-970, S of Marquesas Keys, Straits of Florida, in 512 m (2.5 X).
55. Paratype, MCZ 281477, GERDA station G-966, SW of Marquesas Keys, Straits of Florida, in 553-558 m (2.5 X).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DESCRIPTION: Shell large (to 54 mm), elongate, moderately heavy; spire angle 35°-38°; protoconch of nearly 2 whorls, glassy, bulbous, with indistinct transition to teleoconch of 6 convex, strongly shouldered whorls; suture adpressed; peripheral keel passing through rounded, angulate, and into nodulose stage within first post-nuclear whorl; shell periphery with incised furrow that is most prominent between axial nodes; spiral sculpture of numerous fine threads on body whorl, with stronger cords appearing on posterior portion of the siphonal canal; axial sculpture of 12-16 low ribs per whorl; growth striae fine, weakly sinuate; aperture ovate; outer lip smooth; inner lip smooth, covered by a thin glaze; siphonal canal long, thin, axial, with distal portion dorsally deflected; shell color dingy white to very light tan; periostracum, operculum and soft parts unknown.

ETYMOLOGY: Named after the type locality of Cape Fear, North Carolina. L. *timor* — fear.

TYPE SPECIMENS: Holotype — USNM 87487, length 57.1 mm; Paratype 1 — USNM 821508, length 36.3 mm; Paratype 2, Staples collection — length 45.2 mm; Paratype 3 — DMNH 153516, length 53.6 mm.

TYPE LOCALITY: ALBATROSS sta. 2676, Off Cape Fear, North Carolina, 32°39'N,77°01'W, in 407 fathoms (744 m).

GEOGRAPHIC DISTRIBUTION (fig. 38): This species is known only from off the coast of North Carolina in the vicinity of Cape Fear.

ECOLOGY: The four specimens were taken at depths ranging from 700 to 744 meters.

MATERIAL EXAMINED: ALBATROSS sta. 2676, Off Cape Fear, North Carolina, 32°39'N,77°01'W, in 744 m (USNM 87487 — holotype; USNM 821508 — paratype); Off Cape Fear, North Carolina, in 700 m (Staples collection — paratype); Off North Carolina, in deep water (DMNH 153516 — paratype).

MEASUREMENTS OF SHELL CHARACTERS (n = 3):

	length	width	# whorls	spire angle
mean	46.2 mm	12.3 mm	8.1	36.7°
range	45.2-57.1	10.4-14.8	7.5-8.5	35°-38°

COMPARATIVE REMARKS: This species, first collected during the ALBATROSS cruises, has been misidentified for nearly a century as *Fusus schrammi* Crosse, a tropical, subtidal *Fusinus* from Guadeloupe. Although superficially resembling a small *Fusinus*, its columbarine protoconch and incised periphery show that it is referable to *Peristarium*. *Fulgurofusus (Peristarium) timor* most closely resembles *F. electra*, but the large size, fine spiral sculpture, rounded body whorl and prominently furrowed periphery of *F. timor* distinguish it from other members of the subgenus.

DISCUSSION

The lack of a sharp distinction between protoconch and teleoconch, even in Paleocene species of *Fulgurofusus*, indicates a long history of direct development. The smooth shell and dorsally deflected siphonal canal of *Peristarium* appear to be adaptations for burrowing, while the wide peripheral keels and long, delicate spines of *Fulgurofusus* s.s. and *Histricosceptrum* strongly suggest a purely epifaunal habitat. Major predators are crabs and drilling gastropods, as evidenced by frequent examples of shell repair and naticid as well as muricid boreholes.

Columbarines are morphologically well adapted for feeding on tubiculous polychaetes, a diet confirmed by the presence of serpulid and chaetopterid setae in the rectum of *F. brayi*. Schacko's (in Martens, 1881) illustrations of the "radular teeth" of *Columbarium spinicinctum* are clearly depictions of polychaete setae. The long siphon and large osphradium are indicative of acute chemoreceptive ability, while a long, narrow proboscis, small buccal mass, and strong retractor muscles extending to the columellar muscle appear to be adaptations for extracting prey from its tube. The rachidian, with a basal plate that is greatly expanded and buttressed in opposition to the stout, conical cusps, is well suited to withstand a pulling force perpendicular to the cusps. Lateral teeth are long, recurved, and raptorial. Secretions of the large salivary glands may include a narcotizing agent similar to that found in certain Buccinaceans (Fänge, 1960). The narrow diameter of the esophagus and nerve ring suggest that prey is either limited to small worms swallowed whole, or is eaten in fragments. A large, expanded rectum contains an accumulation of setae.

Little is known about reproductive biology, other than that the open sperm ducts of the male are a primitive feature (Ponder, 1973:316).

Initial inclusion of certain columbarine species in Turridae was due to the mistaken identification of polychaete setae, taken from the proboscis, as toxoglossan radular teeth. Transfer of the group to the Muricidae was based on superficial similarities of shells and radulae, but the lack of accessory salivary glands, accessory boring organ and purple hypobranchial gland show that the Columbariinae are not referable to this calciocavitating family. Although the Columbariinae's affinities with the Buccinidae are closer, the presence of an anal gland and an open sperm groove serve to differentiate it from that family. The family Columbariidae was erected (Tomlin, 1928:330) and family status supported (Ponder, 1973:329) on grounds that the group could not be included in Muricidae or Buccinidae.

Comparison of the morphology of *Fulgurofusus (Fulgurofusus) brayi* with that of certain turbinellids [*Turbinella pyrum* (Linnaeus), Dall, 1885; Moses, 1923; *Turbinella laevigata* Anton, Bayer, 1971; Harasewych, unpublished observations; *Cyomesus chaunax* (Bayer) Bayer, 1971; Harasewych, unpublished observations] reveals close correspondence in such features as: presence of long, folded proboscis and non-evertable proboscis sheath;

similarity in radular morphology; lack of accessory salivary glands; presence of anal gland and open or partially fused sperm groove; diet of tubiculous polychaetes. These and other similarities leave little doubt that the group merits no more than subfamily status within the Turbinellidae.

Earliest records of the Columbariinae are from the Upper Cretaceous and early Tertiary of western Europe, the United States, and New Zealand, and are roughly contemporary with the first appearance of other turbinellid groups (Wenz, 1941). The genera *Fulgurofusus* and *Columbarium* were well established by the Paleocene, and were both members of subtropical, offshore communities. The disappearance of Columbariinae from the post-Eocene fossil record dates the retreat of the group into deeper water. Australian Miocene records are from deep water facies (Darragh, 1969:65).

After the closing of the Tethys Sea in the early Tertiary, the genus *Columbarium* was restricted to the Indo-Pacific, while *Fulgurofusus* retained a wider distribution. Reports of species of *Fulgurofusus* from off New Zealand (Darragh, 1969:104) and the South Orkney Islands are here interpreted as part of an abyssal, circum-Antarctic distribution originating from east Tethyan stock. Based on an examination of the figures, *Columbarium tomicici* McLean and Andrade, 1982, recently described from off western South America, appears to be referable to *Fulgurofusus* s.s., and is likely an offshoot of the Eocene *F. merriami* or *F. washingtonianus*.

The subgenus *Histricosceptrum*, known only from the Recent fauna, is very similar to *Fulgurofusus* s.s.. With the exception of a single Indian Ocean species placed tentatively in this subgenus, all other species are restricted to the Caribbean. The subgenus *Peristarium* is also known only from the Recent of the western Atlantic. Its similarity to certain species attributed to *Coluzea*, especially from the Eocene of Europe and the Recent of South Africa, indicates that further work is required to delineate more precisely the relationships of this group.

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